

Growth and Phenological Development of Rough Fescue in Interior British Columbia

DARRYL G. STOUT, ALASTAIR MCLEAN, AND DEE A. QUINTON

Abstract

Growth and phenological development of rough fescue (*Festuca scabrella*) in interior British Columbia have been documented for a 3-year period. The plants began growing around mid-April and normally ceased growing in late June. Culm growth began in late May and ceased at approximately the time leaf growth ceased. However, leaf and culm elongation ceased before the plants reached their full weight. Rough fescue headed out between May 14 and June 10 and seed shattering occurred between July 13 and July 24. Seed head production per plant was variable from year to year. Fall regrowth occurred in September one year, in October another year, and not at all the other year.

Rough fescue (*Festuca scabrella*) is an important forage species on 1,275,000 ha of grasslands in interior British Columbia, providing up to 10% of the dry matter yield of the *Agropyron-Poa* or middle grasslands zone and up to 50% of the dry matter yield of the *Agropyron-Festuca* or upper grasslands zone (Tisdale 1947). Rough fescue requires a mesic environment and is therefore most abundant on north and east facing slopes.

As rough fescue is a palatable forage and has an extensive fibrous root system for holding soil, it may be advisable to manage it as the key species when it makes up more than 15% of the total plant composition (Hodgkinson and Young 1973). Traditionally the middle and upper grasslands of interior British Columbia have been utilized for spring and fall grazing. To help resource managers make the best use of these rough fescue ranges, we have conducted experiments to document the growth characteristics and the resistance to herbage removal of rough fescue. In this paper we describe the pattern of vegetative and reproductive growth of rough fescue at two sites of interior British Columbia. Possible relationships between growth and environmental parameters are also considered.

Materials and Methods

Study Areas

The Hamilton enclosure, fenced in 1931, is located 70 km south and 26 km east of Kamloops, B.C., on a 49% southeasterly slope at an elevation of 1,158 m, and has a Black Chernozemic (Haploboroll) soil with a sandy loam texture. The East Mara enclosure, fenced in 1938, is located 5 km west of Kamloops, B.C., on a 20% northeast slope at 854 km elevation and has a Black Chernozemic (Haploboroll) soil with a sandy loam texture (McLean and Tisdale 1972).

Authors are forage physiologist, range ecologist, and range scientist, Agriculture Canada, Range Research Station, 3015 Ord Road, Kamloops, B.C. Canada, V2B 8A9.

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Environmental Measurements

Rain gauges, and monthly thermographs (model 251C or 252C Wilh. Lambrecht Ltd., Gottingen, West Germany) housed in Stevenson screens, were maintained at each site from April 1 to October 31 to monitor rainfall and air temperature. Soil temperature was sampled at 10 and 50 cm depths, biweekly from April to October and periodically throughout the winter with a battery operated telethermometer (model 43TE, Yellow Springs, Inst. Co. Inc., Yellow Springs, Ohio). Soil samples, from gravimetric moisture content determination, were collected biweekly from April to November at 5 and 25 cm depths.

Vegetative Growth Measurements

Each year 30 rough fescue plants at a site were identified with labelled stakes. Yield at each site was determined by harvesting 20 plants to a 5-cm stubble at weekly intervals during the plant growth period. The 20 plants were divided into two groups of 10 plants. Plant tissue from the 10 plants within a group was bulked, dried at 80° C and weighed.

In addition to determining the pattern of biomass accumulation, 10 of the 30 plants were randomly chosen to determine the pattern of leaf and culm growth. Average leaf and culm length, measured from ground level, were recorded weekly for each of the 10 plants. When the culm was not visible the length of the outermost leaf sheath was measured, as it would represent the upper limit for the culm length.

Reproductive Growth Measurements

An additional 30 plants were labelled at each site and used to observe flowering and seed production. The dates of developmental stages (boot, head, flower, and seed) were visually estimated. The boot stage occurred when seed heads were enclosed by the leaf sheath. Early heading was defined to be when 10% of the heads from all plants had come out of the boot, and full heading was defined to be when 90% of the heads were out of the boot. Early flowering was defined to be when 10% of the heads were flowering and full flowering was defined to be when 90% of the heads were flowering. At the end of the flowering the anthers discolored and dried up. Seed development was evaluated by estimating the dates when 50% of the seeds were in the milk, dough, ripe, and shattering stages. To quantitatively evaluate reproductive growth, the number of heads per plant were counted for each of the 30 plants. Numbers of tillers and basal areas per plant were also determined to evaluate whether or not the number of heads per plant was related to plant size.

Results

Environmental Conditions

East Mara is a warmer site than Hamilton (Table 1). September and October air temperatures in 1972 were cooler than during 1971 and 1973 at both sites. May and June average daily air temperatures were lower during 1972 than during 1971 or 1973 at Hamilton. At East Mara, April and May air temperatures were lower in 1972 than in 1971 or 1973.

Table 1. Air temperature and precipitation at two interior British Columbia sites during 1971, 1972, and 1973.

Measurement	Site	Year	Months							Mean for May to Oct
			Apr.	May	June	July	Aug.	Sept.	Oct.	
Average daily temperature (°C)	Hamilton	1971	—	9	11	15	19	10	6	12
		1972	—	2	6	14	17	9	3	8
		1973	4	8	11	14	17	11	4	9
	East Mara	1971	7	12	13	18	22	12	7	14
		1972	3	11	15	18	20	11	6	14
		1973	7	13	15	19	21	15	7	15
Total rainfall (cm)	Hamilton	1971	—	2.9	5.3	0.8	1.6	1.6	3.7	15.9
		1972	—	2.2	6.2	1.6	4.2	1.8	2.5	18.5
		1973	0.4	1.5	2.6	0.2	0.5	1.8	3.0	10.0
	East Mara	1971	—	3.0	4.2	2.1	1.7	1.8	1.0	13.7
		1972	0.9	2.5	4.5	3.1	3.2	1.9	0.9	17.1
		1973	0.3	1.9	3.0	0.4	0.9	2.3	2.1	11.0

Soil temperatures, at 10 cm, were generally lower at Hamilton than at East Mara (Fig. 1). Soil temperature began to increase at about the same time in April at both sites but it decreased sooner in September at Hamilton. East Mara had higher summer soil temperatures, especially during June, than Hamilton. During winter the Hamilton soil froze at 10 cm but not at 50 cm, whereas East Mara soil did not freeze at 10 or 50 cm (50 cm data not shown). At East Mara mid-April soil temperature was higher in 1973 than in 1971 or 1972 and September-October soil temperatures were lower in 1972 than in 1971 or 1973.

Total rainfall during May to October was highly variable from year to year at both Hamilton and East Mara (Table 1). Hamilton received more rain than East Mara in 1971 and 1972. May and June rainfall was least in 1973 at both sites.

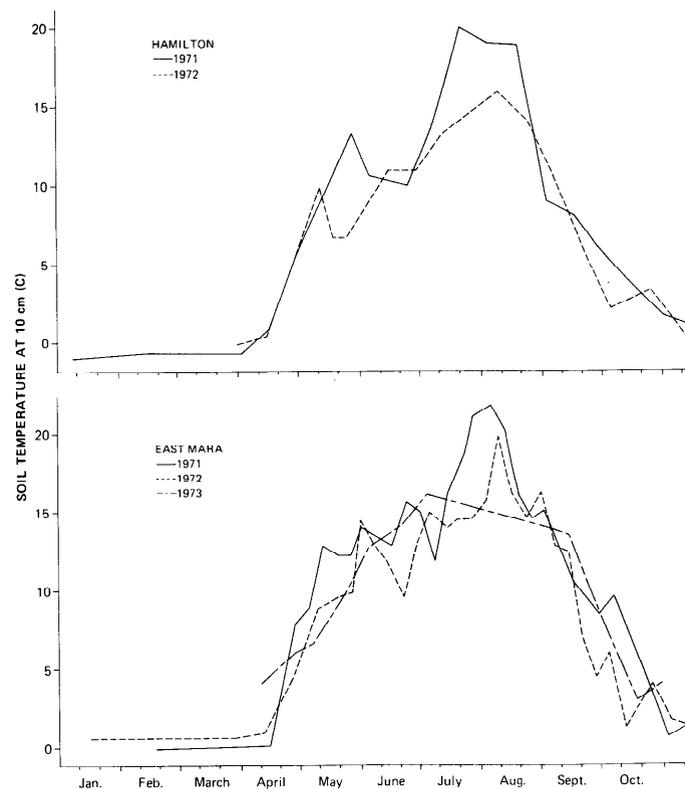


Fig. 1. Soil temperature at a depth of 10 cm for Hamilton during 1971 and 1972 and for East Mara during 1971, 1972, and 1973.

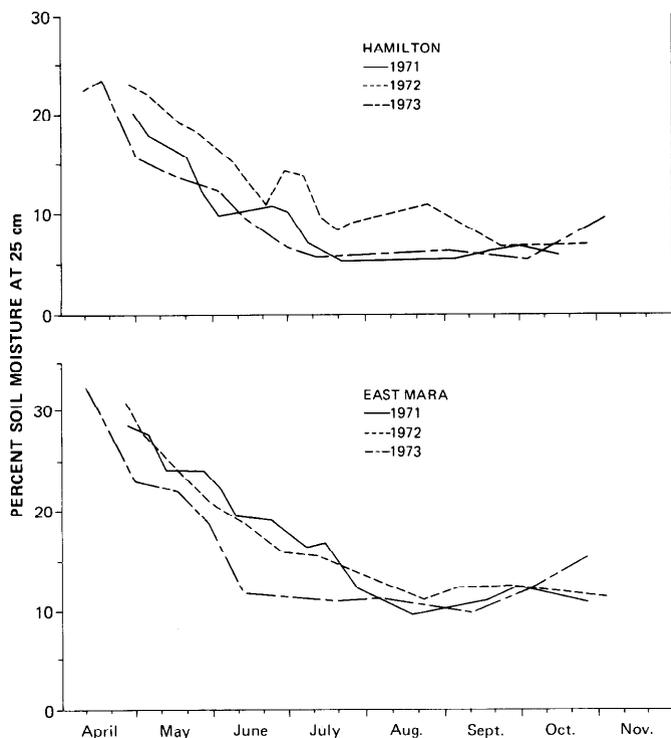


Fig. 2. Soil water content at a depth of 25 cm for Hamilton and East Mara during 1971, 1972, and 1973.

Soil water content was maximum in the spring (April) and then decreased during the summer (Fig. 2). Soil water content decreased most rapidly from April to June or July and then less rapidly during the rest of the summer and fall. Summer and fall rains were not sufficient to return the soil water content to the early spring values. However, the soil was fully recharged with water following snow melt in April. Soil water content at 5 cm reflects the rainfall pattern, and so is highly variable during the year (data not shown). Therefore, soil water content at 25 cm was used for comparison of sites and years. At East Mara and Hamilton, September had a lower soil water content in 1973 than in 1971 or 1972 (Fig. 2); whereas, October soil water content was higher in 1973 than in 1971 or 1972. In general the soil water content was lower in 1973 than in 1971 or 1972 at both sites. The higher soil water content at East Mara likely reflects the soil clay content there and not that it has more available water than Hamilton.

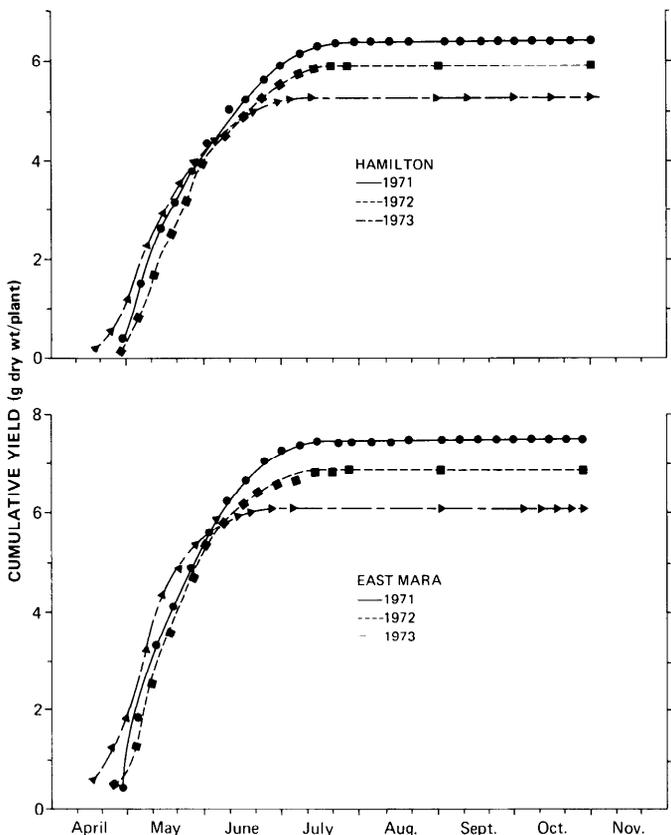


Fig. 3. Cumulative yield at Hamilton and East Mara during 1971, 1972, and 1973. Value are \bar{x} for two groups of plants each containing 10 plants. $LSD_{.05}$ equalled 0.4 g, 1.0 g, and 0.7 g during 1971, 1972, and 1973, respectively.

Vegetative Growth Weight

Date of growth initiation in the spring was estimated by extrapolating the growth curves presented in Fig. 3 to zero yield. Visible growth began during the period April 10 to 25 at both sites (Fig. 3). At Hamilton growth was initiated earlier in 1973 than in 1971 or 1972. At East Mara growth occurred earliest in 1973 and latest in 1971. Soil temperature at 10 cm depth and at the time of growth initiation was $2.9 \pm 0.9^\circ\text{C}$ at East Mara and $2.6 \pm 0.1^\circ\text{C}$ at Hamilton.

Total yield was greater at East Mara than at Hamilton (Fig. 3). At both sites most growth occurred in 1971 and least growth in 1973. In this experiment, where yield was measured, no fall regrowth occurred.

Leaf Length

Extrapolating leaf length curves to zero length suggests that leaf growth was initiated between April 1 and 15 (Fig. 4). This period for growth initiation is slightly earlier than the period estimated from yield data. However, it is more difficult to extrapolate the leaf data because the initial portions of the curves are not as linear as was observed for the yield data. Generally, rough fescue initiates growth within 7 to 10 days of April 15 at both study locations. The specific date within this period varies with year. There is no indication that growth initiation occurs at a different time at East Mara than at Hamilton, despite the fact that Hamilton is 304 m higher in elevation. Ranking of final leaf length for sites and years corresponds to ranking of final yield with the exception that leaf length at East Mara was the same in 1972 and 1973, whereas yield was larger in 1972 than in 1973.

Cessation of leaf length growth was estimated by two methods (Table 2): (1) visual field observations, and (2) measuring leaf length and estimating when the leaves reached their final length by determining on which date each year the average leaf length was

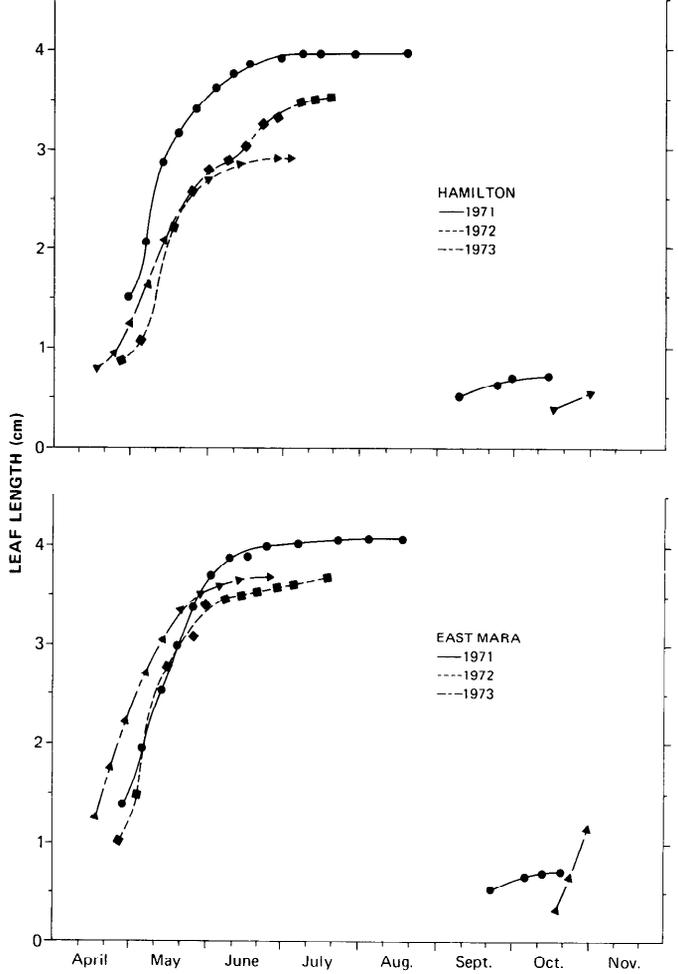


Fig. 4. Growth in leaf length at Hamilton and East Mara during 1971, 1972 and 1973. Values are \bar{x} for 10 plants. At Hamilton $LSD_{.05}$ equalled 1.5 cm, 1.5 cm, and 1.5 cm during 1971, 1972, and 1973, respectively, and at East Mara $LSD_{.05}$ equalled 2.2 cm, 1.3 cm, and 1.6 cm during 1971, 1972, and 1973, respectively.

significantly different from the final length using Duncan's multiple range test. The measuring technique estimated that leaf growth ceased from 1 to 2 weeks before it was visually observable in the field. Soil water content at 25 cm when leaf growth ceased was $20 \pm 2\%$ at East Mara and $12 \pm 2\%$ at Hamilton.

In the leaf length experiment, fall regrowth was observed to occur in 1971 and 1973 at both sites (Fig. 4). In 1971 the regrowth began in September, whereas in 1973 regrowth began in October. This suggests that the lack of regrowth in the yield experiment was due to the clipping.

Culm Length

At both East Mara and Hamilton culm elongation was detected in 1972 (Fig. 5). The 10 plants used in this experiment were not a sufficiently large enough number to detect the low rates of seed head production which occurred during other years (Tables 2 and 3). Culm elongation in 1972 was initiated between May 26 and 31 at East Mara and May 18 and 25 at Hamilton. The soil water content at 25 cm was 22% at East Mara on May 26 and 19% at Hamilton on May 18.

Reproductive Growth

Rough fescue reached the full head stage of development during the period May 25 to June 10 at Hamilton, and during the period May 14 to 24 at East Mara (Table 2). Rough fescue was in full flower during the period June 6 to 24 at Hamilton and the period June 5 to 9 at East Mara. Seeds reached the ripe stage during July 5 to 22 at Hamilton and July 3 to 14 at East Mara. Seed shattering occurred during July 5 to 24 at Hamilton and July 3 to 17 at East

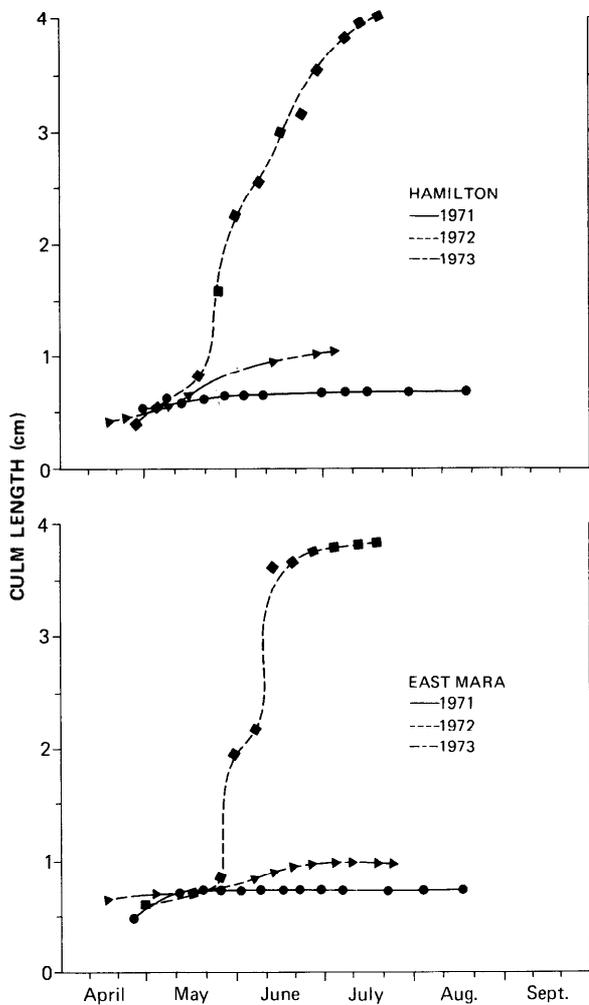


Fig. 5. Growth in culm length at Hamilton and East Mara during 1971, 1972, and 1973. Values are \bar{x} for 10 plants. At Hamilton $LSD_{0.05}$ equalled 1.4 cm, 5.0 cm and 3.9 cm during 1971, 1972, and 1973, respectively, and at East Mara $LSD_{0.05}$ equalled 0.4 cm, 7.6 cm, and 1.0 cm during 1971, 1972, and 1973, respectively.

Table 2. Phenological development of rough fescue at the two interior British Columbia sites during 1971, 1972, and 1973.

Phenological stage ¹	Hamilton			East Mara		
	1971	1972	1973	1971	1972	1973
Boot	May 27	—	May 1	May 12	May 10	Apr 30
Early head	June 3	May 18	May 8	May 19	May 17	May 7
Full head	June 10	May 25	May 30	May 22	May 24	May 14
Early flower	June 17	June 1	May 30	June 2	May 31	May 28
Full flower	June 24	June 15	June 6	June 9	June 7	June 5
End of flower	July 1	June 22	June 13	June 23	June 14	June 12
Seed in milk	—	—	June 29	June 30	—	June 19
Seed in dough	—	July 11	—	July 7	July 5	June 26
Seed ripe	July 22	—	July 5	July 14	—	July 3
Seed shattering	—	July 24	July 5	—	July 17	July 3
Leaf growth ends: estimated visually	June 17	July 7	June 13	June 23	June 28	May 28
estimated from measurements	June 10	June 29	May 30	June 2	June 7	May 28
Fall regrowth begins: estimated visually	Sept. 3	none	Oct. 16	Sept. 15	none	Oct. 3
estimated from measurement	Sept. 9	none	none	Sept. 22	none	Oct. 17

¹Early heading was when 10% of the heads in the boot were pushed out of the boot. Late heading was when 90% of the heads were out of the boot. Early flowering was when 10% of the heads were flowering and full flowering was when 90% of the heads were flowering. The end of leaf growth was estimated visually in the field and was calculated from length measurements using Duncan's multiple range test.

Mara. These results demonstrate that heading occurs earlier at East Mara than at Hamilton, but that seed ripeness and shattering occur during the same period at both sites. Therefore, initial development of reproductive organs occurs more slowly at Hamilton than at East Mara but later development of reproductive organs occurs more rapidly at Hamilton than at East Mara.

Number of heads per plant varied dramatically from year to year (Table 3), making it impossible to detect small differences in number of heads per plant. Thus the only statistically significant difference was the high seed head production at Hamilton in 1972. However, the complete lack of head production at both sites in 1974 probably reflects a real difference compared to 1972 and 1973. Number of tillers and basal area per plant indicate that differences in heading were not due to difference in plant size (Table 3).

Discussion

Growth initiation in the spring may be related to soil temperature. Because soil temperatures in the spring were similar at both sites, it was not possible to demonstrate this by comparing sites. However, years can be compared, since soil temperature differed on a particular date from year to year. In 1973 soil temperature at East Mara increased earlier than in 1971 or 1972 (Fig. 1) and growth was initiated earlier (Figs. 3 and 4). Also the estimated soil temperatures (2.9 ± 0.9 and $2.6 \pm 0.1^\circ\text{C}$) at the time of growth initiation were remarkably similar at the two sites. It has been reported that rough fescue begins growth during May in Alberta when the soil temperature at 20 cm is 2°C (Johnston and MacDonald 1967). Bailey and Anderson (1978) in Alberta observed that rough fescue begins growth soon after snow melt. Growth initiation in the spring would not be limited by insufficient soil water, since soil water content is recharged following snow melt (Fig. 2). At East Mara, April air temperatures were lowest in 1972 (Table 1) yet growth initiation was not dramatically delayed in 1972, especially when compared to 1971 (Figs. 3 and 4). Thus growth initiation appears to be more closely related to soil temperature than to soil water content or to air temperature.

Cessation of rough fescue growth in the summer appears to be related to soil water content. The date for summer growth cessation varied greatly from year to year at both sites (Table 2). However, the soil water content at the time of growth cessation was remarkably similar from year to year at the two sites. Soil water content at the two sites could not be compared since East Mara soil has a higher water holding capacity than Hamilton soil. Yield

Table 3. Number of heads and tillers per plant and basal area per plant at the two interior British Columbia sites during 1972, 1973, and 1974.

Site	Year	Number of heads/plant ¹	Number of tillers/plant ¹	Basal area/plant ¹ (cm ²)
Hamilton	1972	26.5a	300a	84b
	1973	3.3b	241b	83b
	1974	0.0b	216b	80b
East Mara	1972	1.4b	321a	105a
	1973	1.5b	146c	80b
	1974	0.0b	223b	100a

¹Values are \bar{x} for n=30 plants. Different letters indicate significant difference within a column at $P=0.05$ (Duncan's new multiple range test).

continued to increase at low soil water content after leaf growth ceased. This could be expected if growth is being controlled by water supply, since cell expansion is more sensitive to water stress than photosynthesis (Hsiao 1973). Air temperature may also be a factor in growth cessation, since it was quite low at Hamilton during May and June of 1972 and leaf and culm growth continued for a longer than normal period of time at this site in 1972 (Figs. 4 and 5). A lower air temperature would have the effect of decreasing the demand for water. Soil temperature is not high enough at the time of growth cessation to be a limiting factor. In a growth-chamber experiment rough fescue plants showed maximum growth at a soil temperature of 18°C and showed substantial growth at a soil temperature of 27°C (Smoliak and Johnston 1968). Thus rough fescue growth cessation in the summer appears to be mainly controlled by available water.

Rough fescue seed production in Alberta is erratic (Johnston and MacDonald 1967). Erratic seed production might be related to the fact that environmental factors during a rather long time period can affect seed production. For example, seed head initiation occurs in the fall (Johnston and MacDonald 1967), but final seed head development is not completed until the following summer. Seed head production was greatest in 1972 compared to 1973 or 1974 (Table 3). Fall regrowth in 1971 (Fig. 4) showed that fall environmental conditions, at the time when 1972 seed head initiation would be taking place, were favorable at least for vegetative growth. However, 1973 also had fall regrowth (Fig. 4), but no seed heads were produced in 1974 (Table 3). Perhaps it is important that fall regrowth occurred later in 1973 than in 1971. May and June of 1972 were cooler than other years and so the possibility exists that development of seed heads is favored by low temperatures. Unfor-

tunately, the explanation for erratic seed head production is not apparent from our recorded environmental data, or from Johnston and MacDonald's (1967) environmental data. This points out the need to monitor as many environmental parameters as possible and the need to record the complete yearly profile of each environmental parameter in order to determine environmental causes for particular growth responses.

In conclusion, the pattern of growth and phenological development of rough fescue in the interior of British Columbia has been documented for a 3-year period. Growth and phenology of rough fescue varies from year to year and site to site. A particular phenological stage only varies within about a 3-week period from year to year. In this experiment, year-to-year variability was approximately equal to site differences. Thus if a range manager appreciates the yearly variability that can occur at a site, the patterns of growth documented in this paper should be useful for making utilization decisions in most parts of interior British Columbia. For example, the probability that one year's rest from grazing would improve the range by allowing natural reseeding is very low. Range grasses are susceptible to grazing during the growth period, and immediately following growth cessation (Stoddart and Smith 1955). Thus the approximate growth period for rough fescue in interior British Columbia, established in this experiment, identifies when the grazing manager should exercise caution. A study designed to determine specific periods during this growth period when rough fescue is especially susceptible to grazing will be reported on in the future.

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